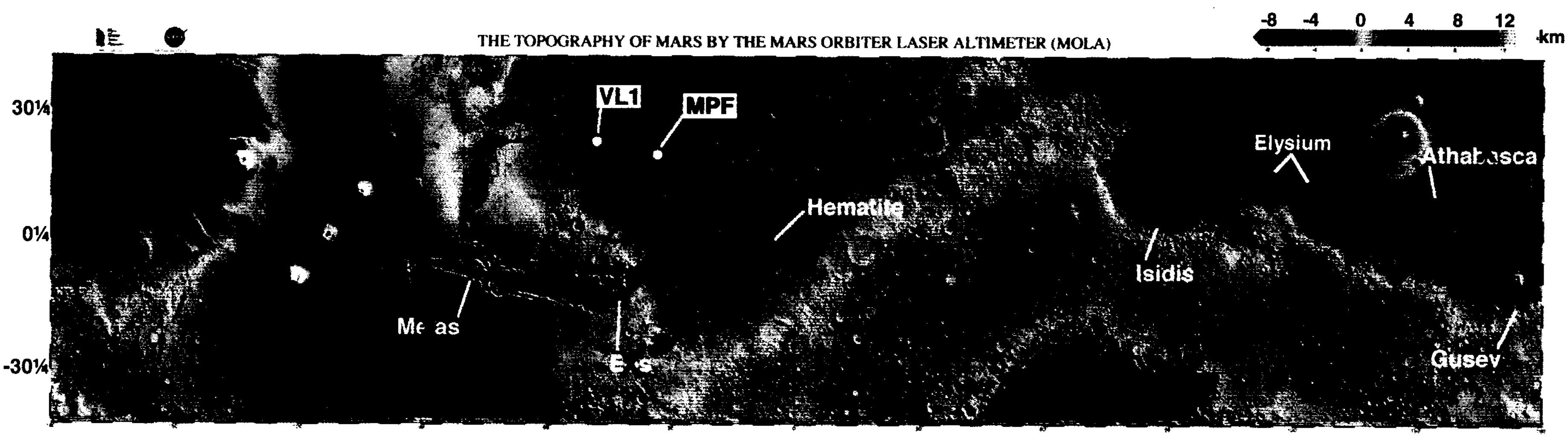
Mars Exploration Rover

Project Update: Engineering Constraints, Mission Design, and Schedule for MER Landing Sites Selection

Joy Crisp

MER Project Scientist

Jet Propulsion Laboratory



EDL Constraints

- Assure adequate drag to reach EDL event conditions before impact
  - Surface altitude < -1.3 km relative to the MOLA geoid
- Assure adequate RADAR reflectivity to get range to actual surface
  - (Thermal inertia constraint covered by temperature requirement)
- Limit variation between RADAR surface altitude 8 sec before landing (used for rocket-firing solution), and actual landing altitude
  - On a 100 m topographic grid horizontal scale, the slopes between grid points shall be less than 5°
- Assure an overall decrease in kinetic energy with time while rolling
  - On a 1 km horizontal scale, slopes shall be less than 2°

EDL Constraints, cont'd.

- Impact survival conditions

  The following are simplified criteria which will be refined after the final set of airbag tests:
  - Total impact velocity < 24 m/s @ no rocks, 16 m/s up to 0.7 m rocks
  - Normal impact velocity < 14 m/s (loads and stroke out)
  - Tangential impact velocity < 21 m/s @ no rocks, 14 m/s up to 0.7 m rocks
  - Grazing angle of impact > 30° or total impact < 10 m/s
  - Benefit from reduced tangential velocities after first impact due to spin up

- Survive more than TBD [90%?] of simulated landing cases
  - Combine **wind, local slope, and rock** effects in a Monte Carlo simulation

Drivers on impact survival

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- Horizontal and vertical velocity of first impact
  - Accuracy of vertical deceleration system RADAR and rockets
  - Wind shear not fully compensated by inertial sensing and TIRS
  - Sustained winds in bottom few km not fully compensated by DIMES and TIRS
- Normal and tangential impact velocities
  - Vertical and horizontal velocity against local slope of each impact
  - Conversion between horizontal and vertical components by local slopes
  - Loss of energy in system due to inelasticity and gradual loss of gas
- Rock size and coverage
  - Largest rock in impact area of 10 to 15 m^2 determines acceptable velocities

Surface Mission Constraints

- Adequate reliability of deployment and rover egress off of lander
  - Affected by immediate slopes and rock abundance
  - Controlled by EDL rock abundance and 5 m scale slope requirements
  - Baseline design has three egress aids—good system performance in test
- Surface mission lifetime and adequate energy for mission success
  - MER-A landing ellipse within 15°S to 5°N latitude
  - MER-B landing ellipse within 10°S to 10°N latitude
- Limit energy needed to maintain thermal control overnight
  - Minimum atmospheric temperature 1 m above the surface > -97°C, as estimated from the albedo and thermal inertia
- Adequate UHF data return
  - Avoid MER-A and MER-B seeing the same orbiter at the same time
  - Centers of the A and B ellipses shall be separated by a central angle $\geq 37°$

New Developments

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- No new developments on system performance other than a technical issue with the parachute requiring a redesign. Three different designs will be tested this fall, from which the final flight design will be selected.

- In the midst of reconstituting acceptable level of $ reserves in the Project budget for FY02-03.

- Withdrew a request for Odyssey stereo THEMIS visible imaging of MER landing sites due to the increased risk to GRS.

Global Circulation Model
Search for Additional "Wind-Safe" Sites

"Tiger Team": Bob Haberle & Jim Schaeffer (Ames), Mark Richardson (Caltech), Scot Rafkin (San Jose State Univ.), Leslie Tamppari, Rich Zurek, Tim Schofield, David Kass (JPL), Matt Golombek, and Joy Crisp

Several meetings in April to discuss results from an Ames GCM and a Caltech GCM for Mars, examining those regions that meet our other EDL requirements to identify potential wind-safe sites. We examined 10-sol and 20-sol averages for the relevant time of day and L_s, slices at 1 km and 3-5 km altitudes, wind vectors and speeds, and wind speed standard deviations, even opening up the latitude range to the North (which would result in less mission return).

Expanded the elevation constraint to 0 km MOLA elevation (later retracted). Combination of GCM model results and some additional coarse-scale mesoscale modeling around the Elysium, Isidis, and Hematite regions resulted in our finding just one new acceptable "wind-safe" region Elysium. Two ellipses were chosen for further study and the high-resolution mesoscale runs were completed.

Elysium: 2 km thick convection

Representative MRAMS Mesoscale Model Results

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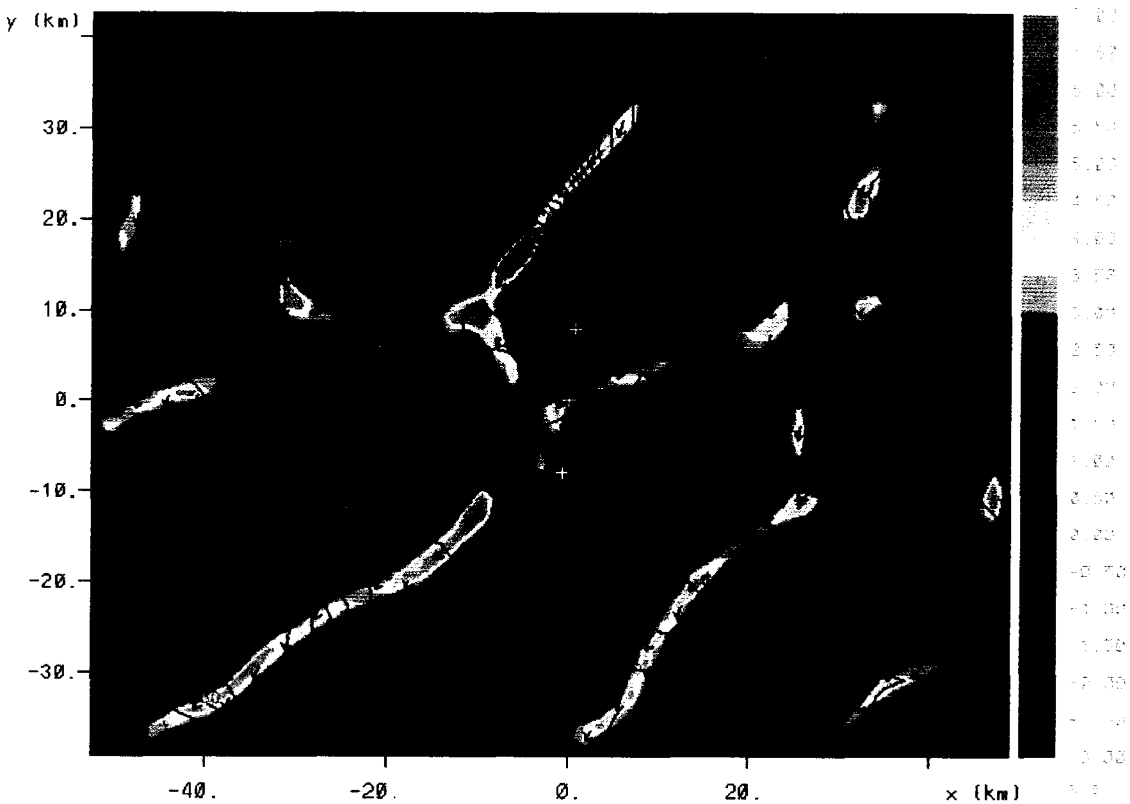
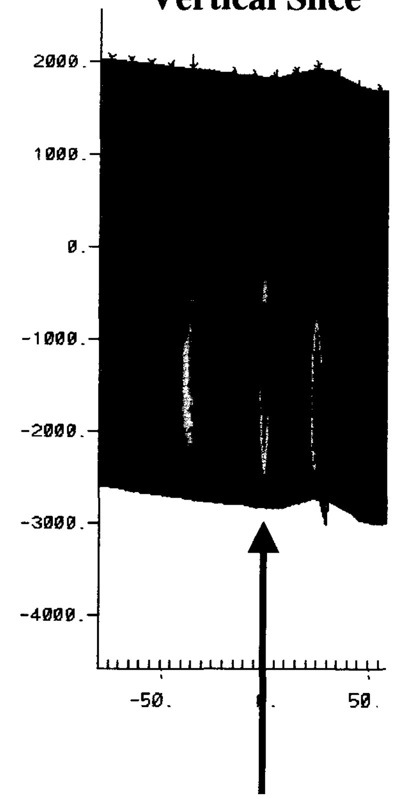
Horizontal Slice @ 1.2 km



Vertical Slice



EP78B2 Center

Elysium 14:16 LTST Sol 2		grid 5			
z = 1290.4 m	199755.00s [0600 UTC +2 sols]	min	max	inc	lab*
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
contours	topo (m)	−3154.	−2430.	40.00	1e 0
vectors →	10 m/s horiz	1.620	12.28		

Mesoscale Wind Modeling Summary

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	Hematite		Elysium		Gusev		Isidis	
	MRAMS	MMM5	MRAMS		MRAMS	MMM5	MRAMS	MMM5
			EP78B2	EP80B2				
Wind Speed (m/s)								
Horizontal	4 ± 2	4 ± 2	**4 ± 2**	**6 + 2**	7 ± 2	3 ± 0.6	14 ± 5	1.3 ±0.7
Upward	2.5	1.4	**0.3**	**0.4**	0.4	0.3	0.7	0.1
Downward	-1.1	-1.7	**-0.2**	**-0.3**	-0.2	-0.3	-0.8	-0.1
MPF Parameter Scale Factors								
Shear*	0.4	0.2	**0.3**	**0.4**	0.9	0.5	0.8	0.5
Turbulence*								
Average	0.7		**1.8**	**1.6**	1.8		1.6	
Peak	1.2		**2.2**	**1.8**	2.1		2.8	

* Shear is long wavelength variability. Turbulence is short wavelength variability. Mean Turbulence is over the convective boundary layer.

LV Targets and Retargeting at TCM-1

JPL

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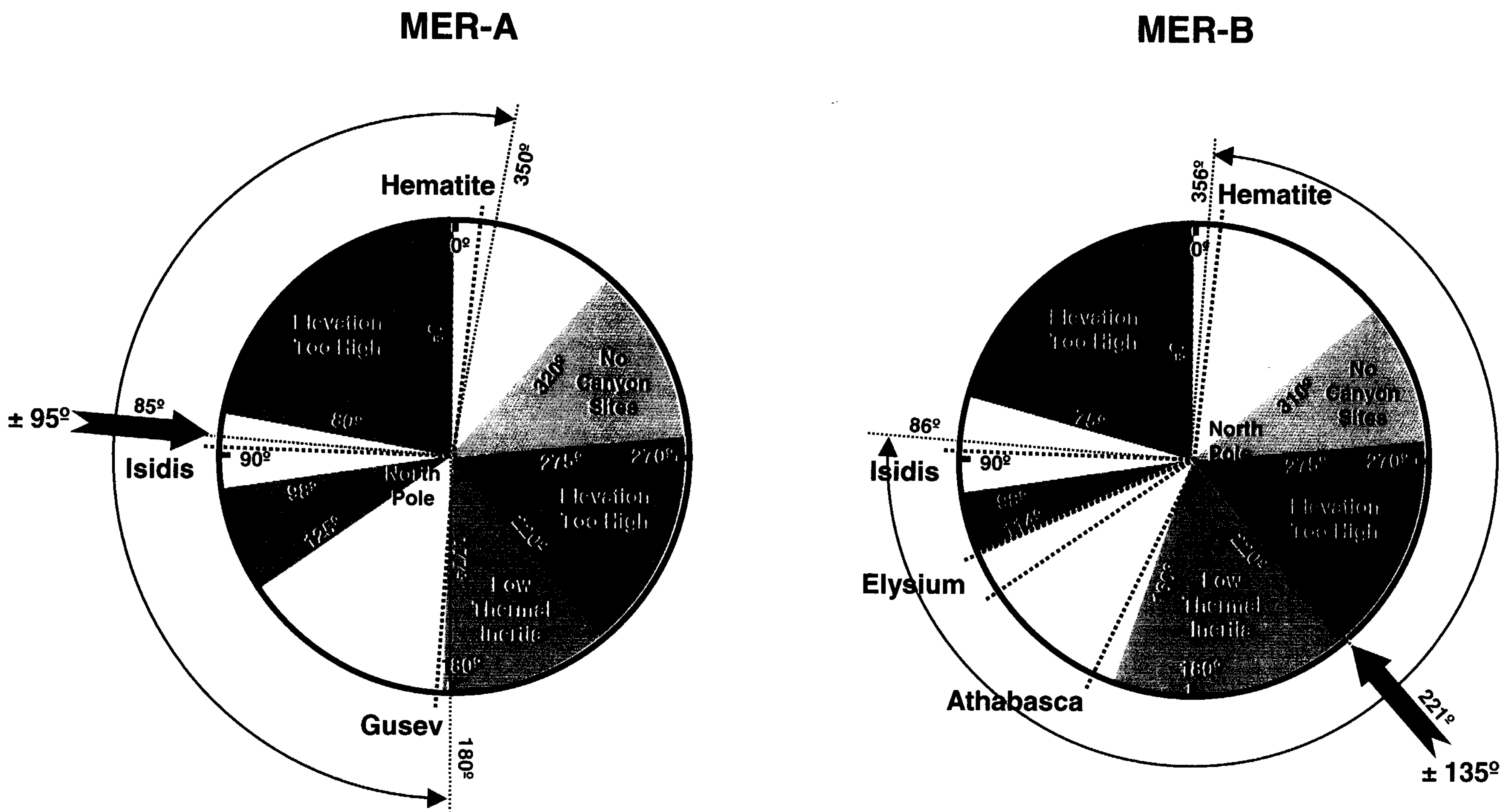

Landing Site Selection Schedule

- Slope Modeling Peer Review September 6, 2002
- Entry, Descent, and Landing (EDL) Simulation Peer Review September 16, 2002
- Prototype Presentation of the Hematite Site Dry Run Dec. 11-13, 2002
- Prototype Presentation of the Hematite Site for Dr. Weiler at HQ Dec. 18, 2002
- 4th Landing Site Workshop & Steering Committee Meeting Jan. 8-10, 2003
- Project/PSG Preliminary Site Certification and Recommendation Jan. 24, 2003
- Landing Site Certification and Recommendation Peer Review Feb. 4-5, 2003
- Project/PSG Final Site Certification and Recommendation, March 3, 2003
- Landing Site Selection and Approval at NASA HQ, March 13, 2003